Production of e^+e^- Pairs Accompanied by Nuclear Dissociation in Ultra-Peripheral Heavy Ion Collisions

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Electron-positron pairs are copiously produced by photon interactions in the strong electromagnetic fields of fully stripped colliding heavy nuclei; the field strength at the surface of the ions reaches 10^{20} V/cm! At a center of mass energy of $\sqrt{s_{NN}} = 200$ GeV per nucleon pair, the production cross section is expected to be 33,000 b, or 4,400 times the hadronic cross section.

The electromagnetic fields are strong enough, with coupling $Z\alpha \approx 0.6$, (Z is the nuclear charge and $\alpha \approx 1/137$ the fine-structure constant), that conventional perturbative calculations of the process are questionable. Higher-order corrections should be the largest close to the nuclei, where the photon densities are largest. These high-density regions have the largest overlap at small ion-ion impact parameters, b. Small-b collisions can be selected by choosing events where the nuclei undergo Coulomb excitation, followed by dissociation. The dissociation is also a convenient experimental trigger. Pair production accompanied by mutual Coulomb excitation should occur at smaller b, and have larger higher-order corrections than for unaccompanied pairs.

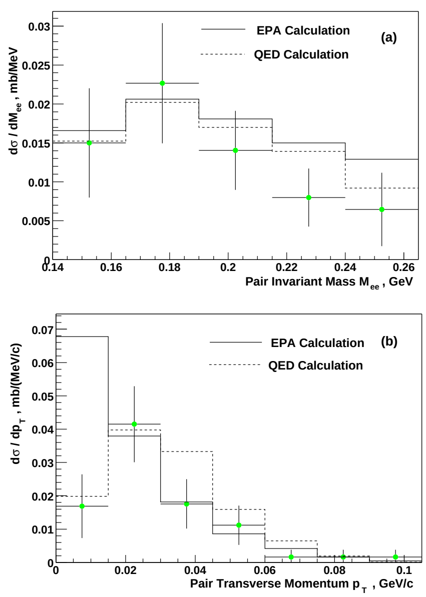

FIG. 1: (a) Pair invariant mass and (b) pair p_T for e^+e^- pairs accompanied by nuclear dissociation.

We study electromagnetic production of e^+e^- pairs accompanied by Coulomb nuclear breakup in $\sqrt{s_{NN}} = 200$ GeV per nucleon pair Au-Au collisions [1, 2]. An e^+e^- pair is produced from two photons, while the nuclei exchange additional, independent photons, which break up the nuclei. We require that there be no hadronic interactions. The Coulomb nuclear breakup requirement selects moderate impact parameter collisions ($2R_A < b <\approx 30$ fm). Except for the common impact parameter, the mutual Coulomb dissociation is independent of the e^+e^- production.

We select events containing exactly two identified-electron tracks that come from a vertex. We find 52 candidate events. The characteristics of these events are compared with two calculations, one based on the equivalent photon approximation (EPA) (e.g. the internal photon lines are massless) and the other based on quantum electrodynamics (QED) The two calculations are similar, except at low p_T. Figure 1 shows the invariant mass and p_T distributions of the pairs. The data agrees with the QED calculation, but not the EPA one in the low p_T region. The pair rapidity and angular decay distributions also agree with the data, and the e^+ and e^- p_T distributions are similar. Within our sensitivity range, the cross section $\sigma = 1.6 \pm 0.2(stat) \pm 0.3(syst)$ nb is in good agreement with the lowest-order QED cross section prediction, σ_{QED}. At a 90% confidence level, higher order corrections to the cross section, $\Delta\sigma = \sigma - \sigma_{QED}$ must be within the range $-0.5\sigma_{QED} < \Delta\sigma < 0.2\sigma_{QED}$.

REFERENCES

[1] Vladimir Morozov, PhD dissertation, UC Berkeley, 2003, nucl-ex/0403002.
[2] J. Adams *et al.* (STAR Collaboration), nucl-ex/0404012.